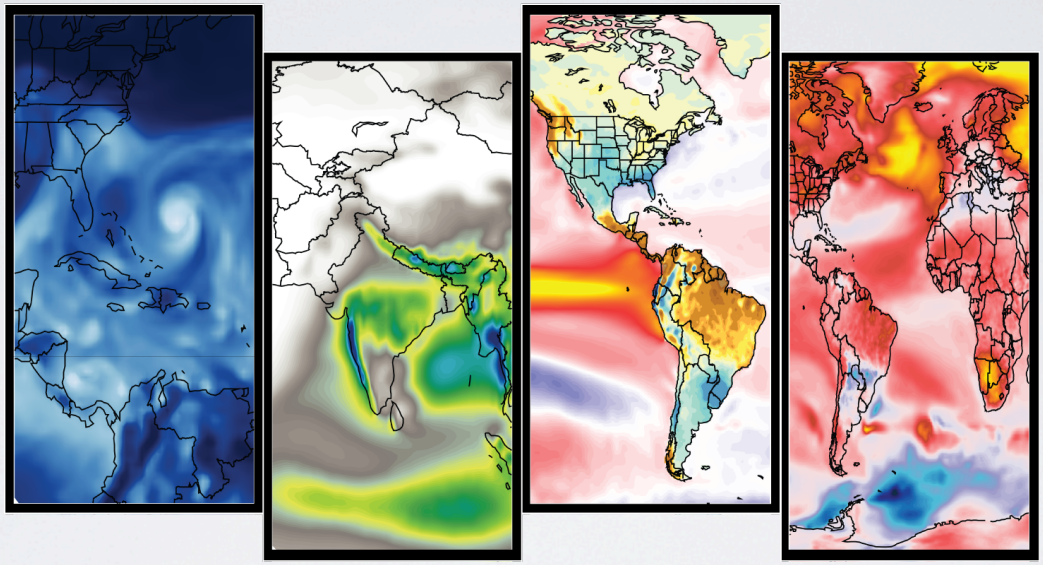
Towards the Prediction of Regional Tropical Cyclone Activity

Gabriel A. Vecchi for NOAA/GFDL Climate Variations and Predictability Group

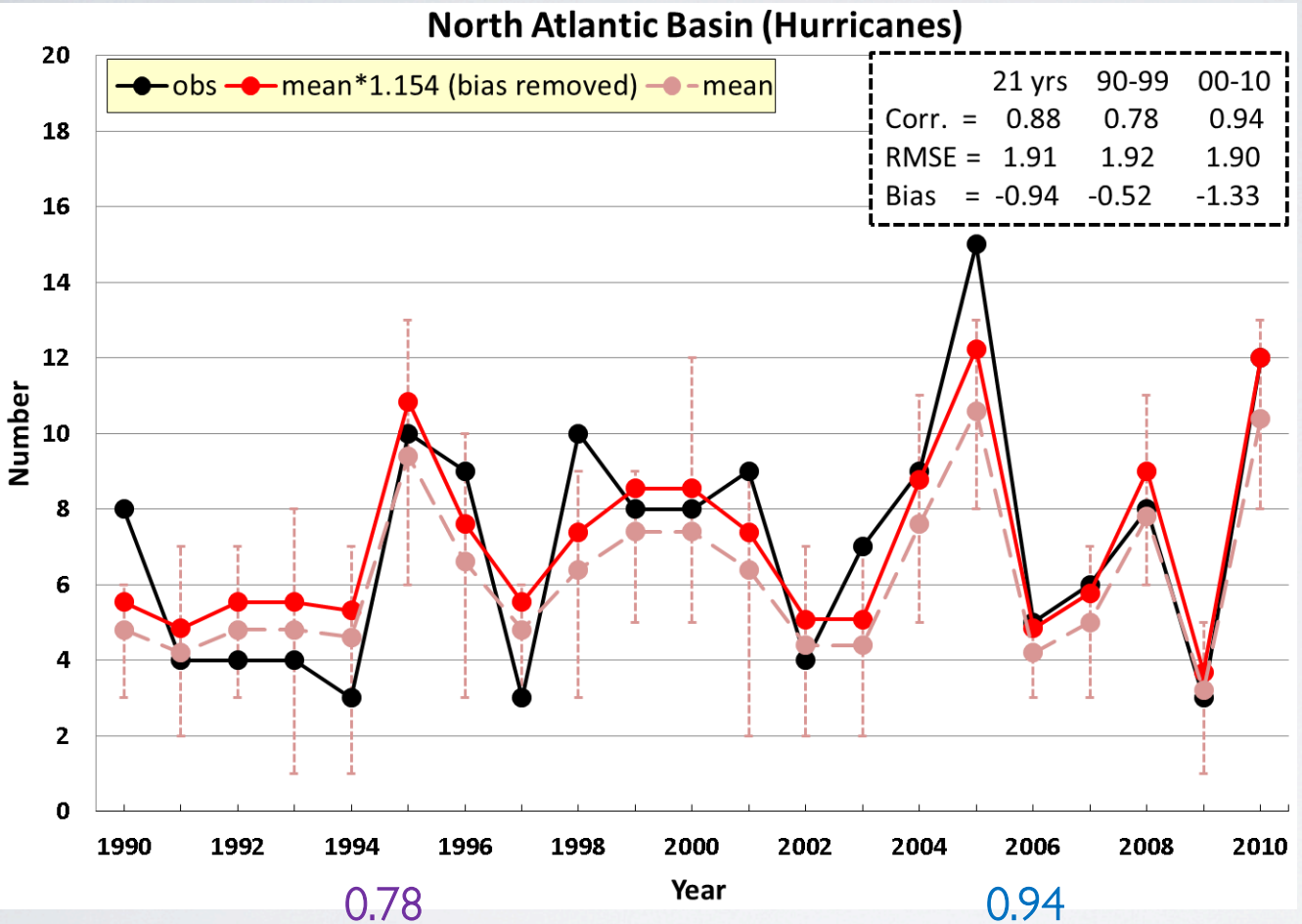


Hypothesis: Enhanced resolution & corrected large-scale climate improve simulation and prediction of regional climate & extremes.

Practical Goal: Build a seasonal to multi-decadal forecasting system to:

- Yield improved forecasts of large-scale climate
- Enable forecasts of regional climate and extremes

25km HiRAM Seasonal hurricane predictions – initialized July 1 1990-2010 (Jul-Nov)



Resolution: 25 km, 32 levels

- 5-members initialized on July 1 with NCEP analysis
- SST anomaly is held constant during the 5-month predictions
- Climatology O3 & greenhouse gases are used

1. Chen and Lin 2011, GRL
2. Chen *et al.*, 2013, J. Clim.

Merge statistical and dynamical models to build experimental long-lead hurricane forecast system: skill from as early as October of year before

April & onward forecasts fed to NOAA Seasonal Outlook Team

Hi-Res AGCM in many different climates. Count storms.

Build statistical model of the response of hurricanes in HiRAM

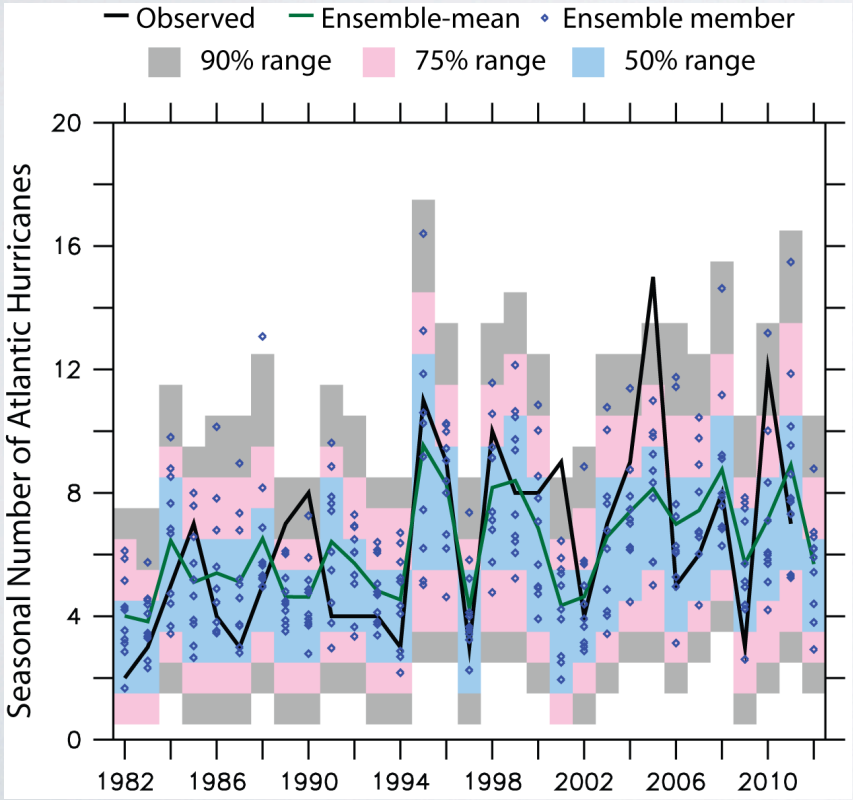
Use initialized coupled model to forecast future values of SST

Apply Stat model to Predicted SST

HyHuFS

Make Prediction of Full PDF of Hurricane Activity

Initialized January: r=0.66

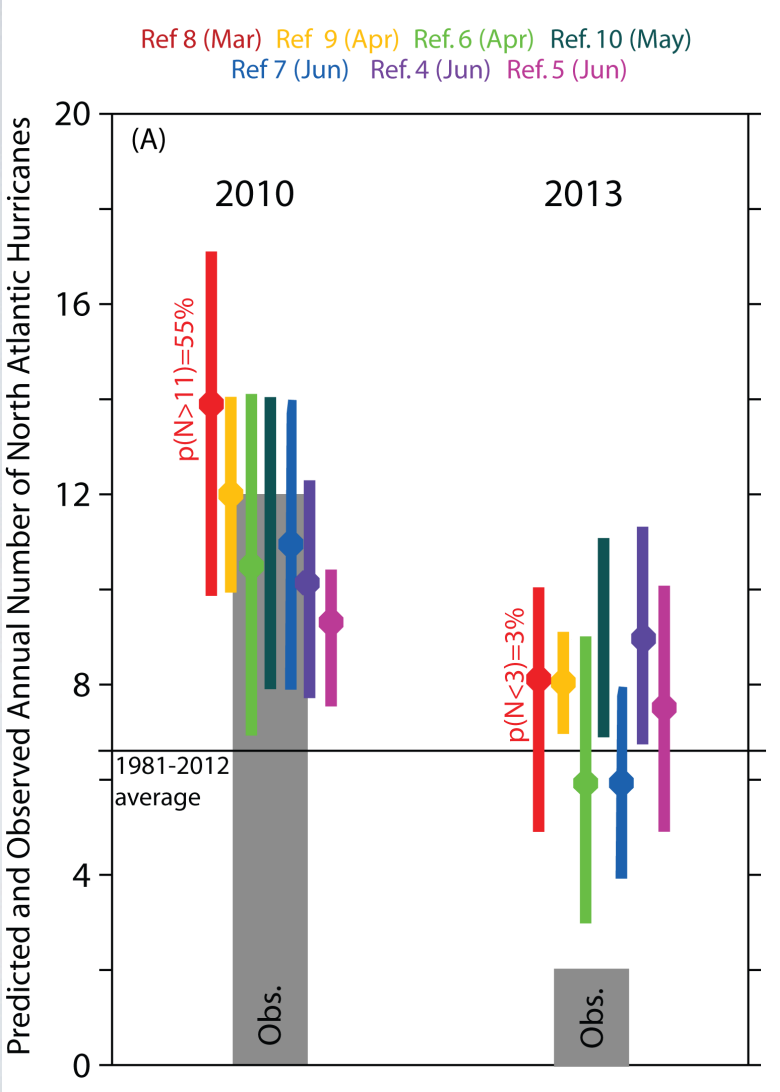


http://gfdl.noaa.gov/HyHuFS

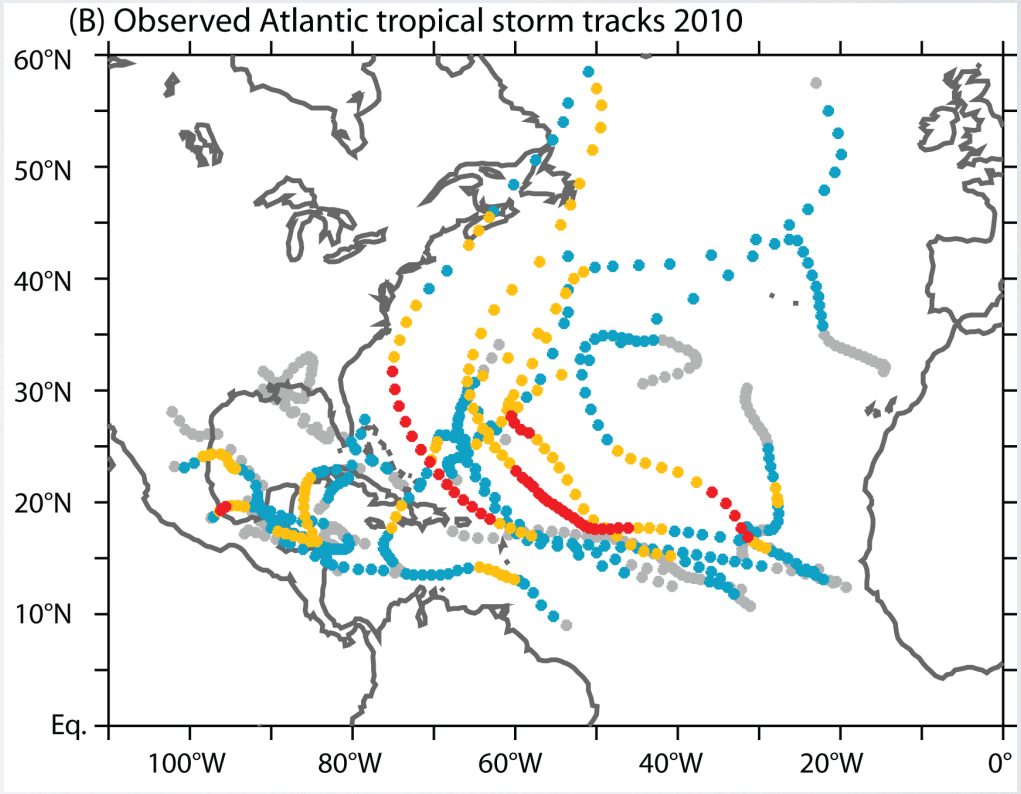
Vecchi et al. (2011, M.W.R.); Villarini and Vecchi (2013, M.W.R.)

Skillful basinwide predictions not necessarily useful predictions.

Can we reliably predict statistics of storms more regionally than "basin-wide" number?



Correct predictions of basin-wide active 2010 but not of U.S. landfall absence

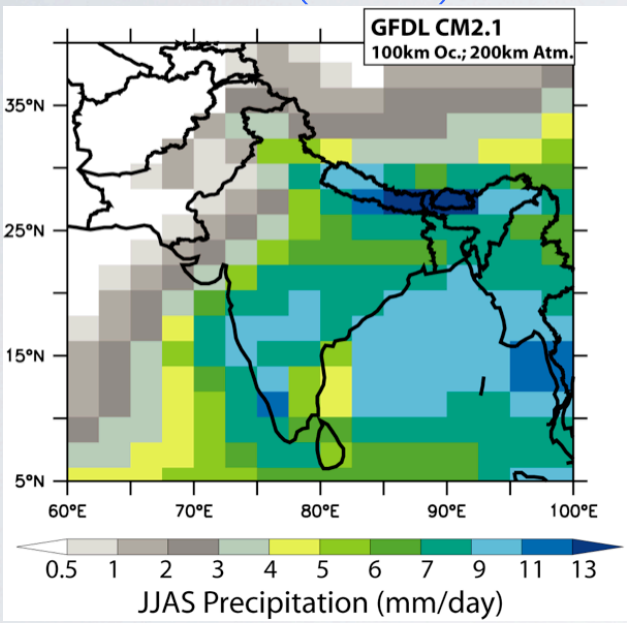


Vecchi and Villarini (2014, Science)

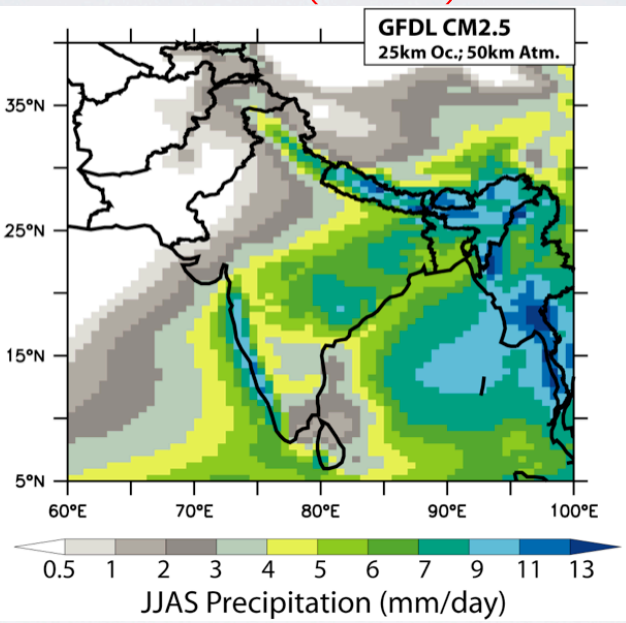
High-resolution GCMs: Going from CM2.1 (1° ocean, 2° atm.) to CM2.5 (0.25° ocean, 50km atm.) improves climate simulation.

E.g., South Asian Monsoon Rainfall Improves with Resolution

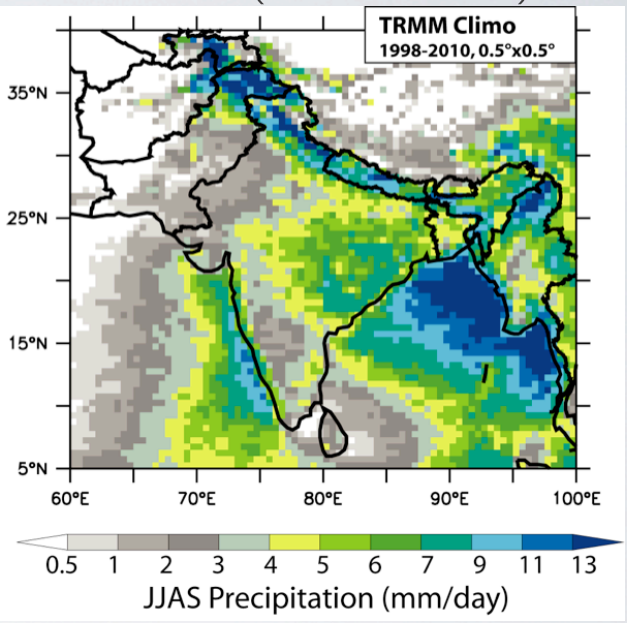
CM2.1 (lo-res)



CM2.5 (hi-res)



TRMM (1998-2010)

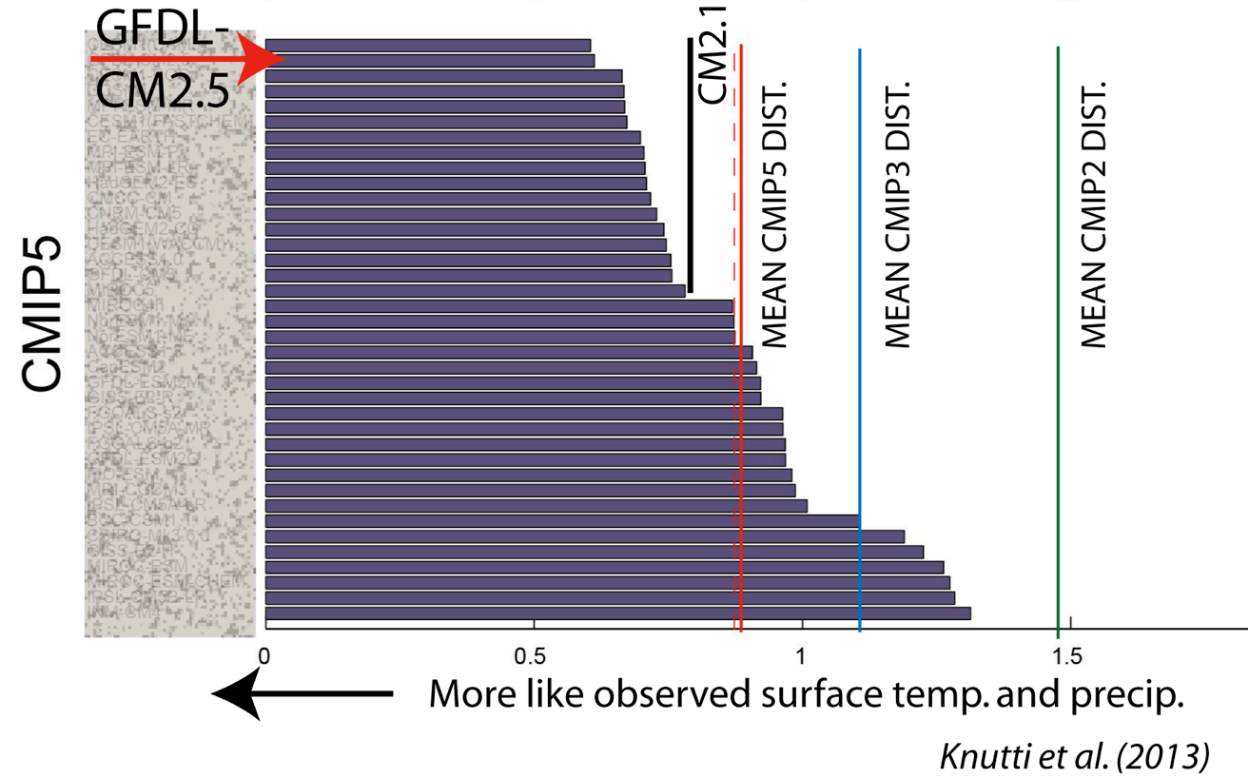


Delworth et al (2012, J. Climate)

CM2.5 produces one of best global surface climate simulations of present model generation: can we harness this for prediction?

CM2.1: 2° atmos/land; 1° ocean/ice, LM2
CM2.5: 50km atmos/land; 0.25° ocean/ice, LM3

Faster computer (GAEA) allows improved resolution that translates into significantly reduced biases in CM2.5 relative to CM2.1

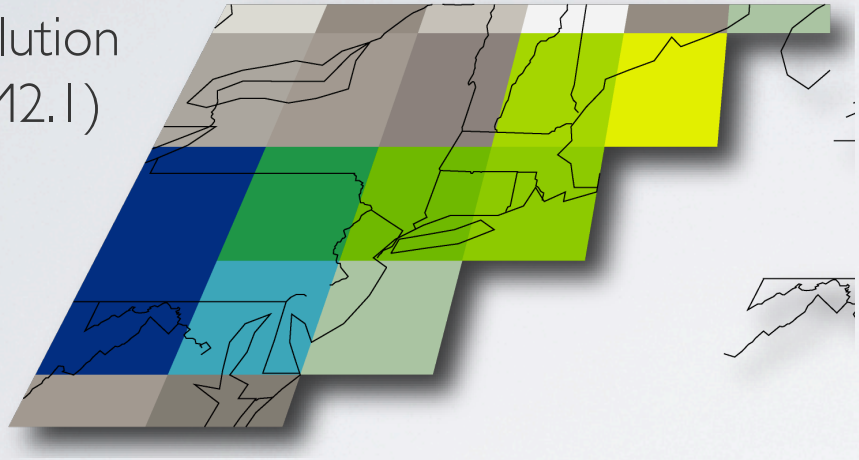


GFDL FLOR: Experimental high-resolution coupled seasonal to decadal prediction system

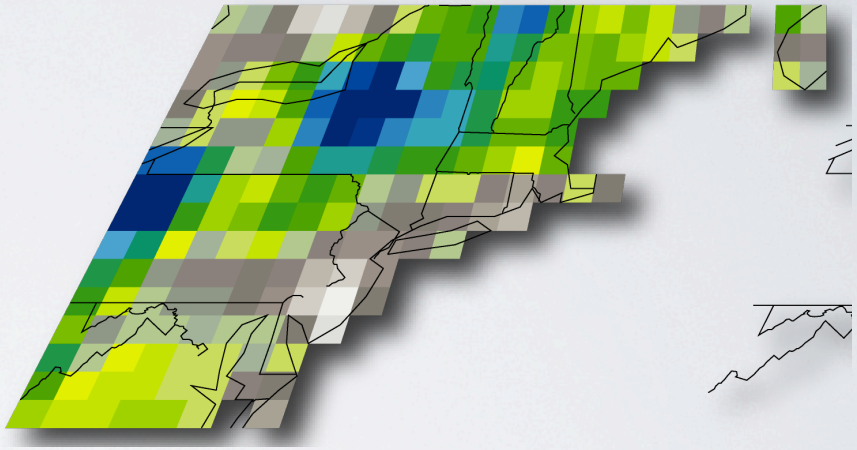
Goal: Build a seasonal to decadal forecasting system to:
Yield improved forecasts of large-scale climate
Enable forecasts of regional climate and extremes

Precipitation in Northeast USA

Medium resolution (CM2.1)



High resolution (CM2.5-FLOR)



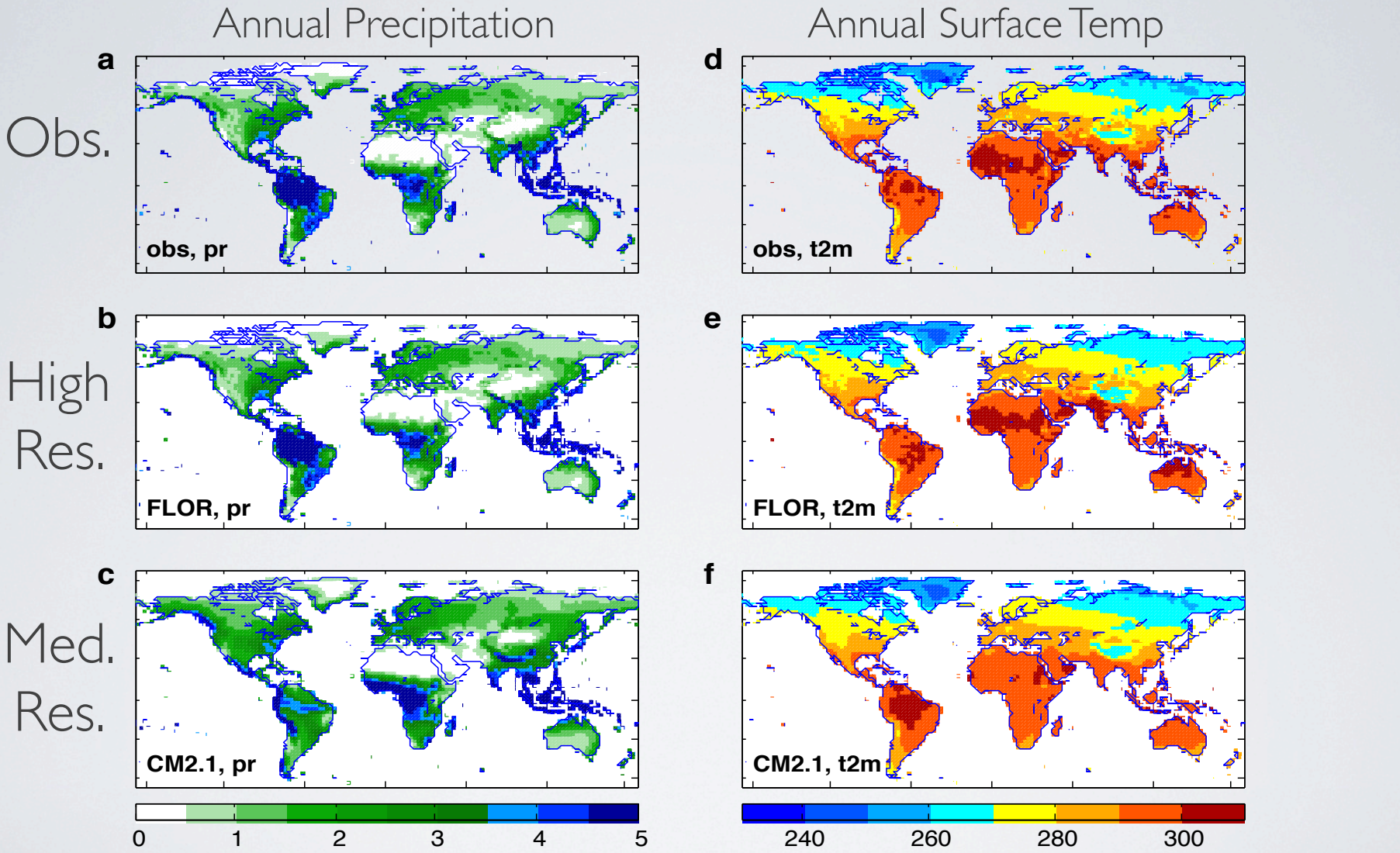
Delworth et al. (2012), Vecchi et al. (2014), Jia et al. (2014)

Modified version of CM2.5 (Delworth et al. 2012):

- 50km cubed-sphere atmosphere
- 1° ocean/sea ice (low res enables prediction work)

~15-18 years per day. Multi-century integrations. 1000s of model-years of experimental seasonal predictions completed and being provided to NMME.

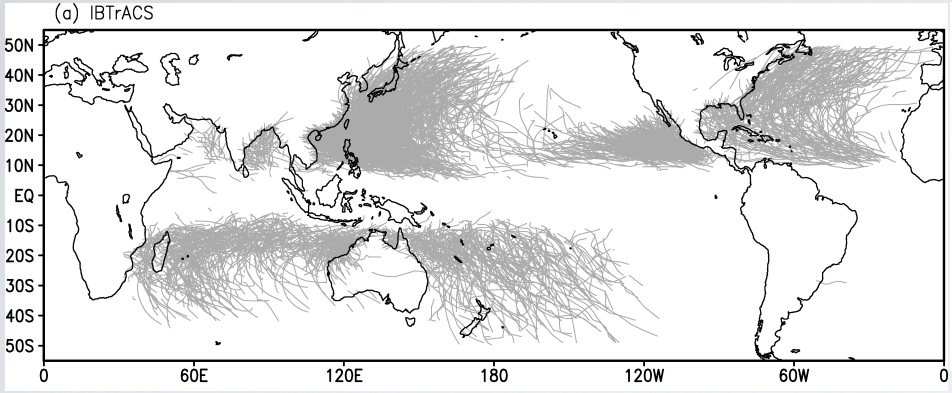
Hypothesis: Enhanced atmos./land resolution improves climate



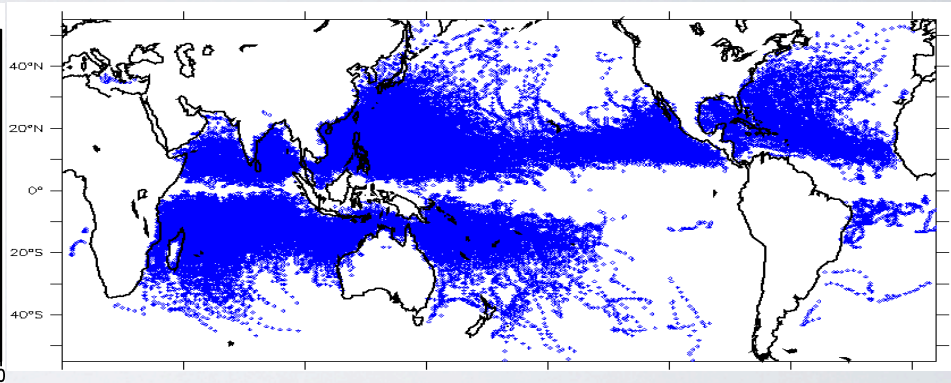
Jia et al. (2014, J. Clim.)

Towards seamless seasonal-to-centennial TC changes in high-resolution global coupled models

Observed Tracks (30y)

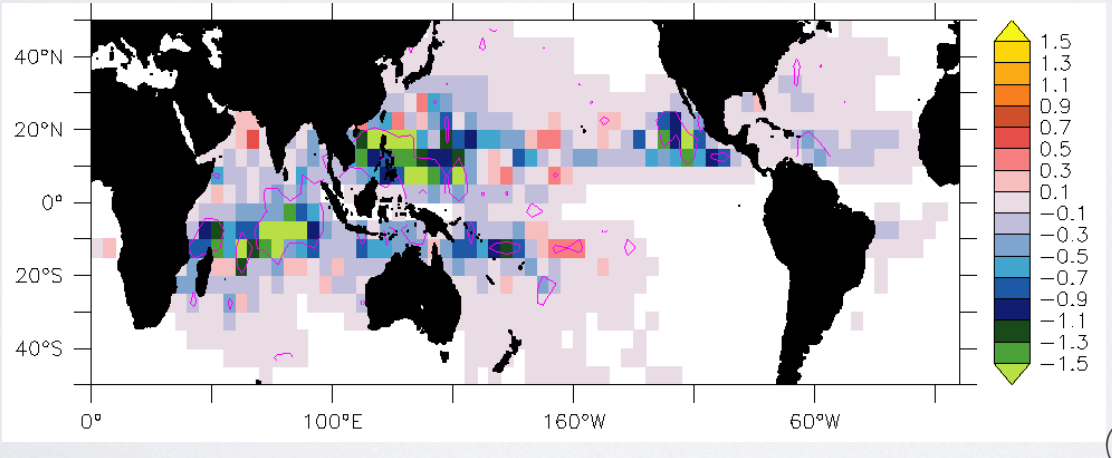


Coupled Model Tracks (30y actual seasonal forecasts)



Vecchi et al. (2014, submitted)

CM2.5 Tropical storm density response to CO_2 doubling



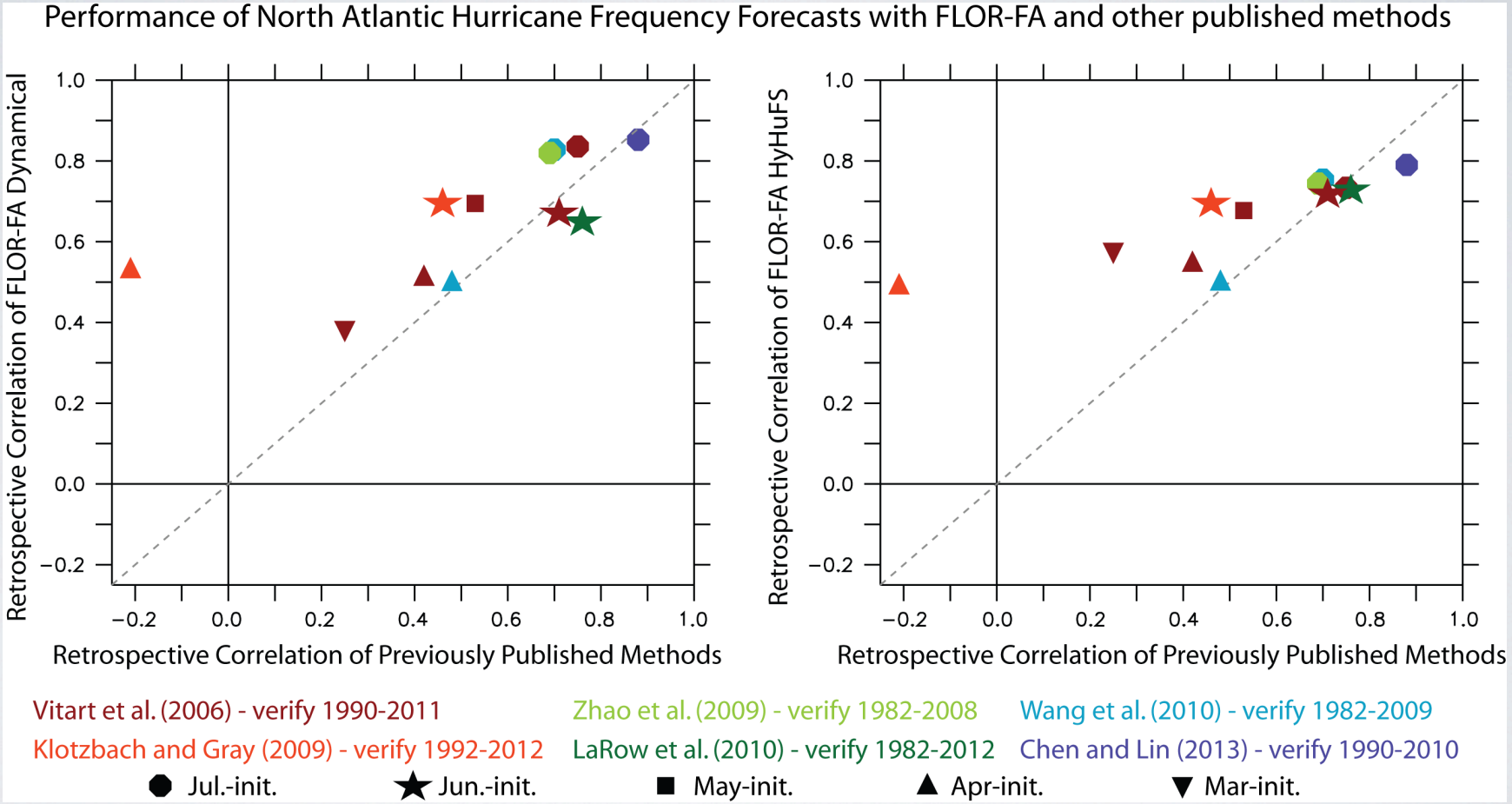
More storms

Fewer storms

(Kim et al. 2014, submitted)

FLOR-FA is among best NA hurricane seasonal prediction systems (symbol above diagonal: FLOR-FA nominally 'better')

FLOR-FA

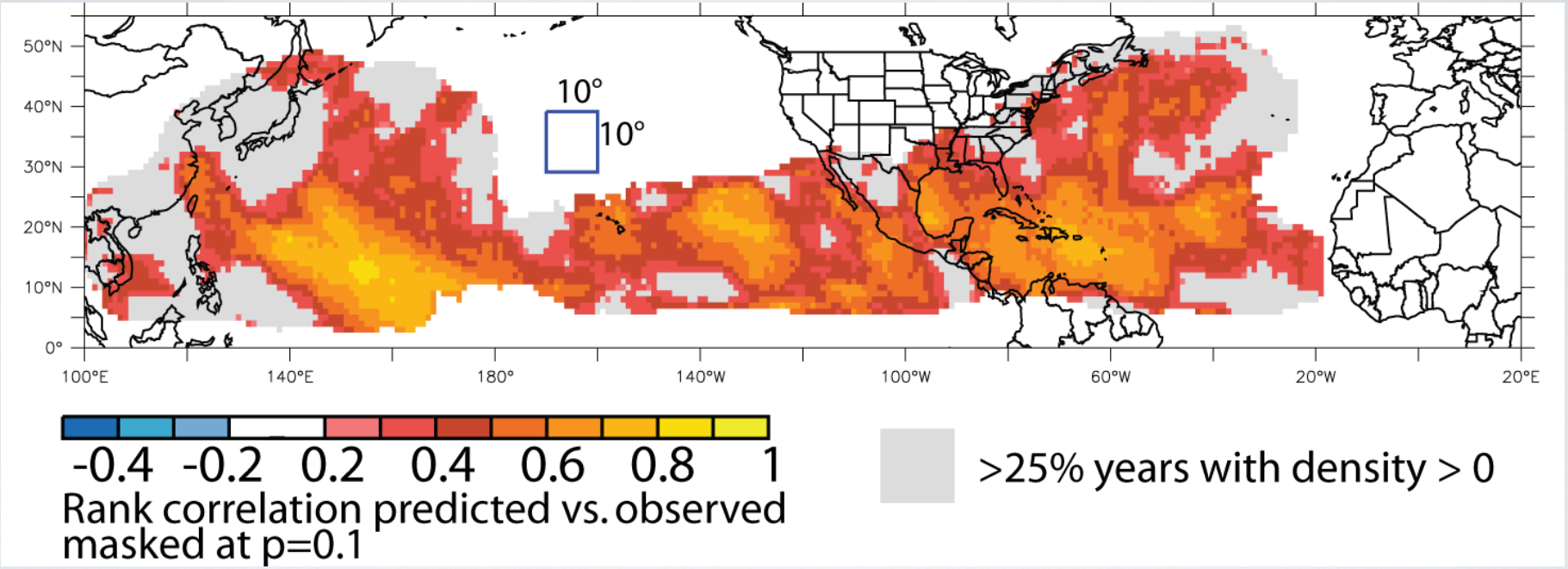


Other systems

Vecchi et al. (2014, submitted)

Can we reliably predict statistics of storms more regionally than "basin-wide" number?

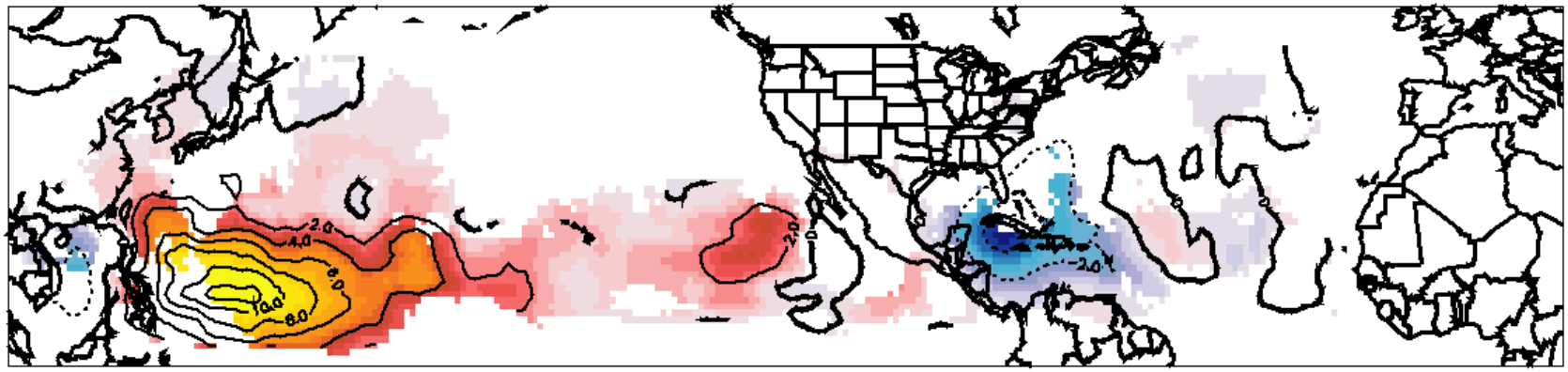
GFDL-FLOR 1981-2012 1-July Initialized Forecasts for July-December



Rank correlation: Can experimental FLOR forecasts distinguish years with many and few storms passing within 10°x10° of a point?

Vecchi et al. (2014, submitted)

GFDL-FLOR-FA Predicted TC density anomaly for 2014, initialized 1-April-2014 reflects in part prediction of strong El Niño



TC density anomaly (days over 10°x10° box for year) relative 1982-2005 shaded indicates regions with retrospective p=0.1 significant correlation. Contoured indicates all values.

Summary

Increased atmospheric and land resolution, and better land model:
Yields improved forecasts of large-scale climate
Enables simulation and forecasts of regional climate and extremes

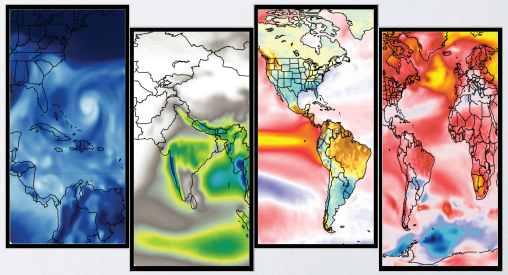
Predictions of regional precipitation and temperature improved by LM3/high-res (and statistical optimization)

Skillful seasonal predictions of TC activity at regional scales appear feasible
Large (many 10s) ensembles appear desirable

Flux adjustment improves simulation and seasonal prediction of regional and climate extremes.
FA adds one season to skill in regional TC prediction

More papers to come on other FLOR results

Papers available here:
http://www.gfdl.noaa.gov/gabriel-vecchi-noaa-gfdl



References

Delworth, T. & coauthors (2012): Simulated climate and climate change in the GFDL CM2.5 high-resolution coupled climate model. *J. Climate* doi:10.1175/JCLI-D-11-00316.1

Jia, L. & coauthors (2014): Improved Seasonal Prediction of Temperature and Precipitation over Land in a High-resolution GFDL Climate Model. *J. Climate* (submitted)

Kim, H.-S., G.A. Vecchi, T.R. Knutson, W.G. Anderson, T.L. Delworth, A. Rosati, F. Zeng, M. Zhao (2014): Tropical Cyclone Simulation and Response to CO2 Doubling in the GFDL CM2.5 High-Resolution Coupled Climate Model. *J. Climate* (submitted).

Knutti, R., D. Masson, & A. Gettelman (2013): Climate model genealogy: Generation CMIP5 and how we got there. *Geophys. Res. Lett.*, doi:10.1002/grl.50256

Vecchi, G.A. & coauthors (2014): On the Seasonal Prediction of Regional Tropical Cyclone Activity. *J. Climate* (submitted)

Vecchi, G.A., & G. Villarini (2014): Next Season's Hurricanes. *Science,* doi:10.1126/science.1247759